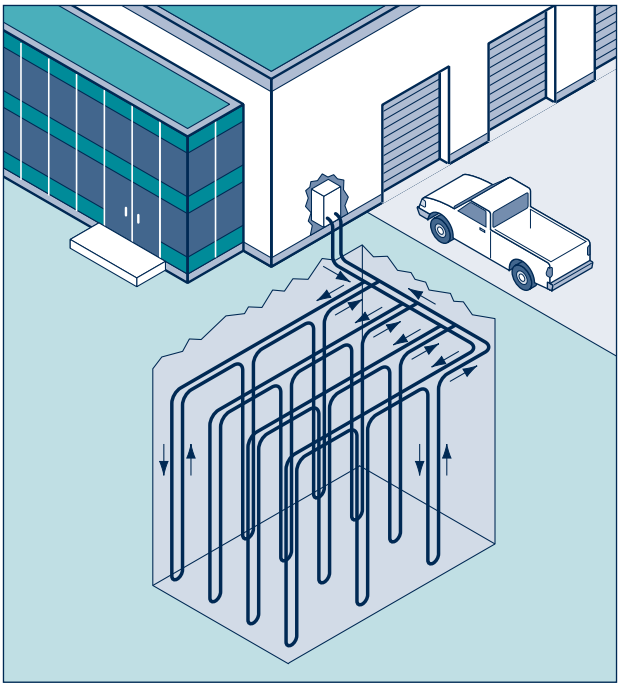
OFFICE OF GEOTHERMAL TECHNOLOGIES

Environmental and Energy Benefits of Geothermal Heat Pumps

Geothermal heat pumps are among the most energy- and cost-efficient heating and cooling systems available today. They use less electricity and produce fewer emissions than conventional systems, reduce air and water pollution, and provide a comfortable indoor environment for building occupants. Nearly 500,000 geothermal heat pumps are being used today for heating and cooling throughout the United States in residential, commercial, and government buildings.



Geothermal heat pumps use the stable temperature of the ground (vertical boreholes typically are 100 to 400 feet deep) as a heat source to warm buildings in winter and as a heat sink to cool them in summer.

Overview

Geothermal heat pumps (GHPs) represent a major clean energy technology. As a commercially viable technology now, GHPs are well positioned to help our nation achieve the increasingly desirable benefits of more efficient, clean energy technologies. While the consumer benefits from the economic and comfort-related benefits of using GHPs, everyone benefits from the substantial environmental and energy benefits resulting from GHP use, especially as GHPs become more widespread in the market. The geothermal heat pump is ideal for residential, commercial, and government building applications. Understanding the environmental and energy benefits of GHPs helps broaden appreciation of the overall potential of this outstanding technology.

Nearly 500 schools nationwide depend on GHPs for heating and cooling. GHPs use less energy and produce fewer emissions than their traditional HVAC counterparts.

Achieving the present market penetration level of nearly 500,000 GHP installations reduces U.S. greenhouse gas emissions by over 1 million metric tons of carbon dioxide each year. In a landmark technical report (source: "Space Conditioning: The Next Frontier," EPA 430-R-93-004, April 1993), the U.S. Environmental Protection Agency (EPA) found that GHPs are the most energy efficient, environmentally clean, and cost-effective space-conditioning systems available. The EPA also found that GHPs offer the lowest carbon dioxide emissions and lowest overall environmental cost of all the residential space-conditioning technology readily available today. The few emissions that are released occur at the power plant, where they are carefully monitored and controlled.

Energy Under Foot

Resource Conservation

Over two-thirds of the nation's electrical energy and over 40% of natural gas consumption is used in buildings. Space heating and cooling and water heating account for over 40% of the electric power used in residential and commercial buildings. By decreasing or offsetting the amount of energy needed for space conditioning and water heating, the nation has a major energy-saving opportunity.

GHPs, also known as GeoExchange℠ systems, move the heat from the earth (or a groundwater source) into the home in the winter, and pull the heat from the house and discharge it into the ground in the summer. The underground (or underwater) piping loops serve as a heat source in the winter and a heat sink in the summer. In essence, it's the same heat-exchanging process used by the common refrigerator or air conditioner.

> *"GHP systems have the lowest carbon dioxide emissions of all technologies analyzed, and the lowest overall environmental cost."*
>
> EPA, 1993

While many parts of the country experience seasonal temperature extremes—from scorching heat in the summer to sub-zero cold in the winter—a few feet below the earth's surface the ground remains at a relatively constant temperature.

Because a GHP system is so efficient, it uses a lot less energy to maintain comfortable indoor temperatures. This means that less energy—often created from burning fossil fuels—is needed to operate a GHP. According to the EPA, geothermal heat pumps can reduce energy consumption—and corresponding emissions—up to 44% compared to air-source heat pumps and up to 72% compared to electric resistance heating with standard air-conditioning equipment for residential applications.

Environmental Benefits

Greenhouse Gas Mitigation and Emissions Reductions

Nearly 40% of all U.S. emissions of carbon dioxide are the result of using energy to heat, cool, and provide hot water for buildings. This is about the same percentage that the transportation sector contributes. The EPA found that under most electricity generating scenarios, GHP systems have the lowest carbon dioxide emissions of all technologies analyzed, and the lowest overall environmental cost (source: "Space Conditioning: The Next Frontier").

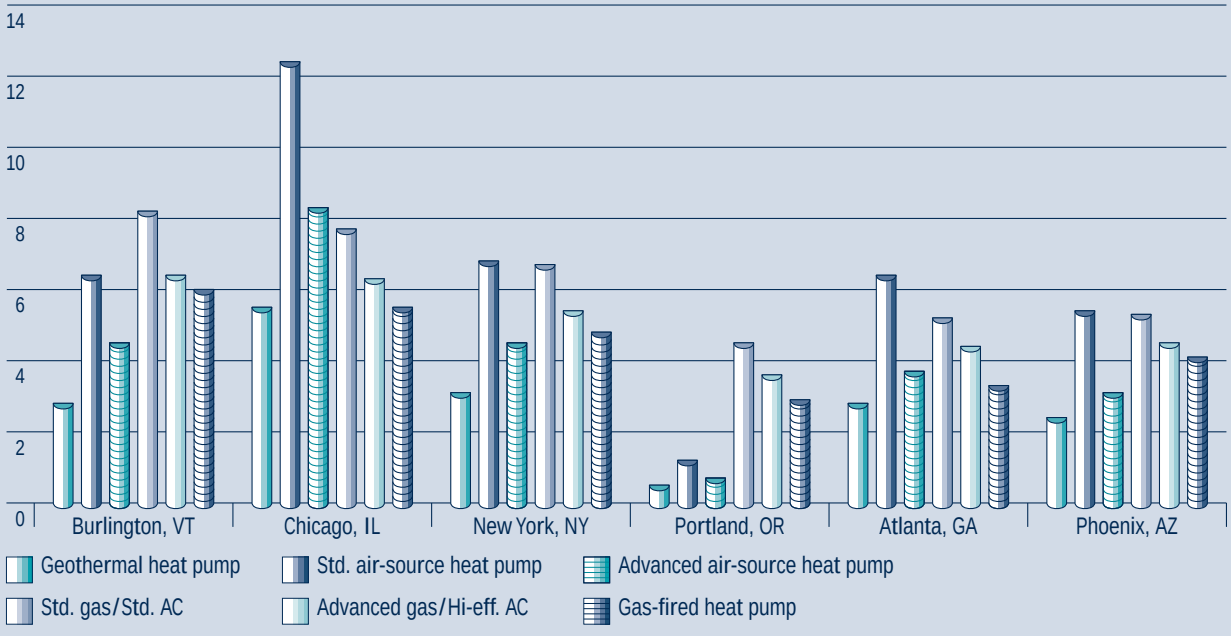
Over an average 20-year lifespan, every 100,000 units of nominally sized residential GHPs will save more than 24 trillion BTUs of electrical energy, and save consumers approximately $500 million in heating and cooling costs at current prices. And over the same period, these 100,000 units reduce greenhouse gas emissions by almost 1.1 million metric tons of carbon equivalents.

Ozone Layer Damage

GHPs minimize ozone layer destruction by using factory-sealed refrigeration systems that will seldom or never have to be recharged. GHPs typically use less

Annual Carbon Dioxide Emissions from Space Conditioning Equipment by Region
(in thousands of kilograms per year)

Source: EPA, 1993



refrigerant than conventional air-conditioning systems. And using factory-sealed refrigeration systems also reduces leak potential from field connections and increases reliability.

Human Health and Comfort

GHPs are safe and clean because there are no combustion flames, no flues, and no odors; just safe, reliable operation year after year. And compared to most conventional HVAC systems, GHPs deliver constant comfort and improved humidity benefits, especially with 2-speed fan GHP systems. GHPs are quiet too; there's no noisy outdoor compressor.

GHP systems themselves are environmentally friendly—when properly installed, there is no danger of GHPs polluting ground water sources. The fluid in the ground-loop heat exchangers is typically an environmentally safe, water-based antifreeze solution. A recent EPA analysis ("Evaluation of Consequences of Antifreeze Spills from Geothermal Heat Pumps," undated EPA report released in late 1998, GPO#1998-615-003/60624) found that the human health risk from ingesting groundwater contaminated by a GHP antifreeze leak is low.

DOE Role

In 1994, the U.S. Department of Energy (DOE), working closely with the EPA, Edison Electric Institute, Electric Power Research Institute, International Ground Source Heat Pump Association (IGSHPA), National Rural Electric Cooperative Association, and industry, helped to create the Geothermal Heat Pump Consortium (GHPC). The GHPC launched the National Earth Comfort Program, designed to foster the development of a fast-growing, self-sustaining, national GHP industry infrastructure. DOE has also supported research and development activities, especially through IGSHPA; the American Society of Heating, Refrigeration, and Air-Conditioning Engineers; the National Ground Water Association; and DOE's national laboratories. The work has targeted several areas of GHP technology, lowering the cost of ground heat exchangers, and developing advanced design software.

In partnership with the GHPC, DOE's Office of Geothermal Technologies seeks to increase annual installations of GHP systems to about 400,000 by 2005 and reach about 2 million installed (cumulative) that same year. Achieving the goal of 400,000 annual installations by 2005 will save consumers over $400 million per year in energy bills and reduce U.S. greenhouse gas emissions by over 1 million metric tons of carbon each year.

PIX06570

This commercial-sized GHP unit, installed in Cavett Elementary School, Lincoln, Nebraska, provides reliable year-round comfort.

Impressive Market Growth

The present installation base of nearly 500,000 GHP systems comprises just a fraction of the technology's potential applications. Today, GHPs represent a rapidly growing sector of the heating and cooling industry. In 1997, the GHPC reported an annual growth rate of 22%. GHP sales grew even faster—24%—during the first quarter of 1998, according to data collected by the Air Conditioning and Refrigeration Institute.

> *"The geothermal heat pump is ideal for residential, commercial, and government building applications."*

A tremendous opportunity exists to reduce energy use and carbon emissions significantly by the accelerated and expanded deployment of GHP systems.

Case Study—Fort Polk Army Base

A great example of a large-scale application of GHPs is the highly successful project at Fort Polk, Louisiana, where 4,003 U.S. Army housing units at Ft. Polk were converted to GHPs. Since the new systems were installed, service calls on hot summer days have dropped from 90 per day to almost zero, testifying to the reliability of GHP systems.

Data were collected on the utility feeders serving the housing area, and on a sample of apartments before, during, and after the retrofits. The GHPs and other efficiency measures reduced electrical consumption by 26 million kWh (average of 6,445 kWh per housing unit) or 32% of the pre-retrofit consumption, as well

as 100% of natural gas consumption. It also reduced summer peak demand by 7.5 megawatts, which is 43% of the pre-retrofit electrical consumption in family housing, and improved the load factor from 0.52 to 0.62. These energy savings correspond to an estimated reduction in carbon dioxide emissions of 22,400 tons per year, which gives project participants "green" bragging rights immediately.

As demonstrated by this Fort Polk project, GHPs shave peak loads and improve load factors. At Fort Polk, the whole-house load factor for a house with gas heating and water heating was 0.32 versus 0.60 for the GHP house.

Financed by Co-Energy Group, a GHP energy service company, the project bears no up-front costs to the government. The $18 million contract was signed in February 1994, and the installation was completed in August 1996. The contractor will receive payments amounting to 80% of the energy savings while providing maintenance during the life of the 20-year contract. For maintenance, the Army will pay Co-Energy about 18 cents per square foot per year, saving the Army about 22% compared with previous maintenance costs.

> *"GHPs can reduce energy use by 23% to 44% compared to advanced air-source heat pumps, and by 63% to 72% compared to electric resistance heating and standard air-conditioning equipment."*

At the time of installation, this project was the nation's largest energy savings performance contract (ESPC). Since this pioneer GHP project, both DOE and the Department of Defense have established a "Super ESPC" program. The agencies, through a competitive bid process, prequalify energy service companies based on past performance and their ability to finance work. Once selected, these energy service companies will be able to sign contracts with any federal agency within a matter of months—much quicker than the normal bid process. DOE's Federal Energy Management Program and Office of Geothermal Technologies have developed a technology-specific Super ESPC for geothermal heat pumps for all federal agencies.

The Fort Polk project received Vice President Al Gore's Hammer Award in 1997 for "hammering away at building a better government"—one that works better and costs less. This award, one of the Clinton Administration's highest, is given to individuals or groups who have demonstrated exemplary reinvention of government.

For More Information

The following organizations serve as excellent resources for information on geothermal energy and its various applications.

U.S. Department of Energy (DOE)
Office of Geothermal Technologies, EE-12
1000 Independence Avenue, SW
Washington, DC 20585-0121
(202) 586-5340
http://www.eren.doe.gov/geothermal/

The Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
(800) DOE-EREC (363-3732)
Fax: (703) 893-0400
E-mail: doe.erec@nciinc.com
http://www.eren.doe.gov/consumerinfo/

Geo-Heat Center
Oregon Institute of Technology
3201 Campus Drive
Klamath Falls, OR 97601-8801
(503) 885-1750
http://www.oit.osshe.edu/~geoheat/

Geothermal Heat Pump Consortium, Inc. (GHPC)
701 Pennsylvania Avenue, NW
Washington, DC 20004-2696
(888) ALL-4-GEO (255-4436)
http://www.geoexchange.org/

International Ground Source Heat Pump Association (IGSHPA)
490 Cordell South
Stillwater, OK 74078-8018
(405) 744-5175
(800) 626-4747
http://www.igshpa.okstate.edu/

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